

## Acute coronary insufficiency *An urgent surgical condition*

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*In 41 of 220 consecutive patients who had a coronary artery bypass operation between July 1973 and March 1974 the operation was for acute coronary insufficiency (recurrent chest pain with transient electrocardiographic changes persisting after admission to hospital). Their mean age was 54 (range 33-70 years). Eleven patients had had angina before, 14 had had at least one myocardial infarction, and 16 presented de novo. Eight of the latter 16 patients required only a single graft, usually to the left anterior descending artery, a significantly greater number than the two of the other 25 patients ( $P < 0.01$ ). Fourteen of these 16 patients had normal ventricular contraction, a significantly higher proportion than the 13 of the remaining 25 ( $P < 0.05$ ). No collaterals were seen in any of the 10 with single-vessel disease, which was significantly fewer than five out of 18 with double- and nine out of 13 with triple-vessel disease ( $P < 0.005$ ). Patients with rapidly developing obstruction, especially in the proximal left anterior descending artery, may not have time to develop collaterals, present acutely with good ventricular function, and may be particularly at risk.*

*There was no operative mortality. Three patients had a perioperative myocardial infarction, and there was one late death. At follow-up averaging 9.7 months (range 5-14 months) 32 (80%) patients were angina-free, no myocardial infarctions had occurred, and 85% were fully employed. Urgent coronary artery bypass grafting is a safe and effective treatment for acute coronary insufficiency.*

Acute coronary insufficiency has been defined as a state in which the coronary circulation is insufficient to meet the full metabolic needs of the myocardium at rest yet sufficient to prevent myocardial infarction (Wood, 1961). It has also been defined as a condition intermediate between chronic angina and acute myocardial infarction (Spencer, 1972). Though first described more than 35 years ago (Sampson and Eliaser, 1937) the clinical presentation was re-emphasized and the natural history of the untreated condition first analysed by Wood (1961). He noted an acute illness (under six weeks) in 50 per cent of cases, a subacute illness (two to six months) in 45 per cent of cases, and a chronic illness in the remaining five per cent of cases. Twenty-two per cent of his patients sustained an infarct within two months of their first symptom and 70 per cent of these infarcts were fatal. The 'sinister record' at five-year follow-up showed that about 50 per cent of his patients had died, 25 per cent were 'relatively well', and 25 per cent had recurring angina.

A recently published prospective 10-year follow-up study of 140 patients, some of whom were on

anticoagulants, showed a 21 per cent infarction rate within three months of the onset of symptoms, fatal in 41 per cent of cases, and a five-year survival of 61 per cent (Gazes *et al.*, 1973) - results which are remarkably similar to those of Wood published 12 years earlier.

With the successful development of coronary artery bypass techniques it seemed natural to offer surgery to these patients, who appeared to have relatively poor prognosis on medical therapy. The results in a series of 41 patients undergoing urgent coronary artery bypass surgery for acute coronary insufficiency form the basis for this report.

### Patients and methods

The 41 patients (36 men and five women aged from 33 to 70 years (mean 54)) included all those treated over a nine-month period in whom angina occurred at rest, pain persisted while in hospital, lasted for more than 20 minutes at a time, and was often not relieved by repeated doses of analgesics and nitrates. Electrocardiographic abnormalities were always present but limited to transient T and ST changes. There was no evidence of recent myocardial infarction in the form of abnormal Q waves or raised serum enzyme levels.

TABLE I Analysis of 41 cases of acute coronary insufficiency

No. of vessels obstructed	No. of patients	Previous history			Collaterals (No.) (%)		LV wall motion			LVEDP > 12 mm
		None	Previous MI	Chronic angina			Dyskinesia			
							None	Local	General	
1	10	8	1	1	0/10	0	9	—	1	1
2	18	4	8	6	5/18	28	11	5	2	3
≥ 3	13	4	5	4	9/13	69	7	3	3	8
Total	41	16	14	11	14/41	34	27	8	6	12

MI = Myocardial infarction. LV = Left ventricular. LVEDP = Left ventricular end diastolic pressure.

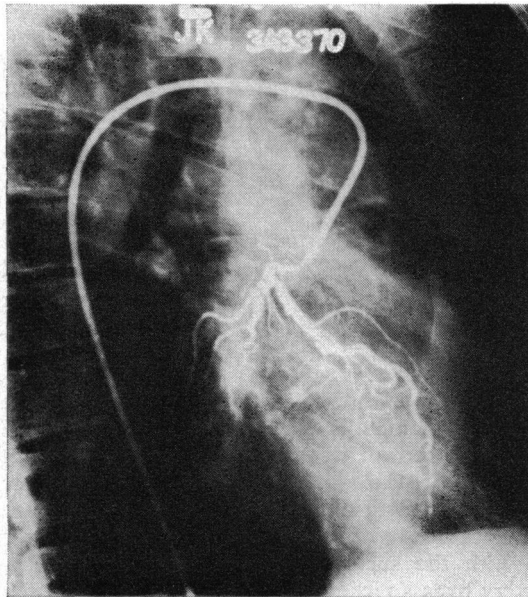


FIG. Left coronary arteriogram, left anterior oblique projection, shows severe proximal stenosis of left anterior descending coronary artery.

All patients underwent left and right heart catheterization, left ventricular and coronary cineangiography, and three-plane cut film coronary angiography using a percutaneous artery approach (Judkins, 1968). Investigations were performed urgently, often within hours of admission, and surgery often immediately thereafter. The operative technique and postoperative management have been described elsewhere (Anderson *et al.*, 1972).

### Results

Of the 41 patients (Table I) 16 presented *de novo*, 14 had had at least one myocardial infarction, and 11

had had chronic angina before the onset of acute symptoms. In 14 of the 16 cases presenting *de novo* symptoms had been present for less than two weeks. Patients with chronic angina had had symptoms for, on average, over four years, which usually became acute over about a week. Eight of the 16 patients with new symptoms required only a single graft, usually to the left anterior descending artery, a significantly greater number than the two of the other 25 patients ( $P < 0.01$ ). Of these same 16 patients, 14 had normal ventricular wall motion at ventriculography, a significantly higher proportion than the 13 of the other 25 ( $P < 0.05$ ). Though the patients with new symptoms were on average 4 years younger than those in the other two groups there was no difference within this group between those requiring a single graft and those requiring multiple grafts.

Collaterals were not seen in any of the 10 patients with single-vessel disease (see Fig.), but were seen in five out of 18 with double-vessel disease and nine out of 13 with triple-vessel disease. These differences were significant at the 0.5% level by a  $\chi^2$  test. Thirteen of 14 patients with left ventricular dyskinesia, either localized or generalized, and 11 of 12 with a left ventricular end diastolic pressure greater than 12 mmHg had disease in two or more coronary vessels. The left anterior descending artery was most commonly grafted vessel, alone on seven occasions and in combination on 30 occasions.

There were two patients in the series with significant left main coronary artery disease and one in whom the heart was totally supplied by a single right coronary artery. Single vein bypass was used in 10 patients (24%) and multiple grafts inserted in 31 patients (76%). Eighty-six out of 88 significantly obstructed vessels were grafted in the 41 patients. The mean duration of hospital stay was 15 days (range 9 to 64).

### Mortality and morbidity

There was no operative mortality but two patients sustained an episode of cardiac arrest before operation.

A 47-year-old man with a two-year history of chronic angina was admitted with coronary insufficiency of a few hours duration only. After admission he developed ventricular fibrillation from which he was successfully defibrillated. Immediate catheterization and coronary angiography was followed by surgical relief of severe stenosis of the left anterior descending and circumflex vessels. He was discharged 15 days later and is currently, a year later, free from pain and fully employed.

A 65-year-old retired man with a previous history of myocardial infarction developed coronary insufficiency which did not respond to admission to hospital and drug therapy. Coronary angiography showed a severe left main coronary artery stenosis and a totally occluded right coronary artery. After catheterization, when about to leave the department, he became hypotensive and developed refractory ventricular fibrillation. He was hurriedly taken to surgery and put on cardiopulmonary bypass while the heart was externally and then internally massaged. After triple vein grafting his convalescence was difficult and prolonged, but he finally went home ambulant and apparently cerebrally intact. He is now free of angina and enjoys an active retirement. Though there were marked enzyme rises in the postoperative period there was no electrocardiographic evidence of transmural infarction.

Table 2 shows the morbidity in the series. Renal failure was defined as a blood urea nitrogen greater than 14.3 mmol/l (40 mg/100 ml) persisting for three consecutive postoperative days and perioperative myocardial infarction was diagnosed in the presence of pathological Q waves or persistent ST and T wave changes in association with raised serum enzyme levels.

### Follow-up

One sudden late death occurred in a 63-year-old man 10 weeks after triple vein grafting. Catheterization before surgery had shown generalized poor

left ventricular wall motion with a left ventricular end diastolic pressure of 23 mmHg. At necropsy patent grafts, myocardial fibrosis without infarction, and patent pulmonary arteries were found. Follow-up of the 40 survivors at a mean of 9.7 months after surgery (range 5–14 months) showed that 32 were angina free, seven had occasional angina, and one had daily angina. Three patients took trinitrin therapy. There was no evidence, symptomatic or documented, of late myocardial infarction. Twenty-five patients had returned to full-time work, one to part-time, and two housewives had been restored to full housekeeping function. Nine patients (7 over 60 years of age) were retired before surgery and three previously employed (aged 48 to 59 years) had not resumed work after operation. Two of these noted occasional angina.

Thus it seems that 85 per cent of patients with coronary insufficiency (retired patients over 60 years of age excluded) had been restored to a gainful working capacity.

### Discussion

The number of alternative terms used for acute coronary insufficiency (preinfarction, accelerated, unstable, crescendo angina, status anginosus, intermediary coronary syndrome) is matched only by the variety of clinical presentations of angina labelled as coronary insufficiency. The need for an objective definition of the condition has been emphasized (Fowler, 1971). We have chosen precise subjective criteria with the added objective criteria of ischaemic changes (Goodin *et al.*, 1973) and significant coronary stenosis in all cases.

Coronary insufficiency is a common condition reported as occurring in from 10–20 per cent of various series of patients with coronary artery disease (Wood, 1961; Krauss, Hutter, and De Sanctis, 1972; Vakil, 1964). Our 41 patients comprised 19 per cent of a series of 220 consecutive patients undergoing coronary artery surgery over a nine-month period. Our results show that of patients with a recent onset of acute coronary insufficiency and no previous cardiac symptoms significantly more had single vessel disease and normal left ventricular wall motion. The development of collateral vessels was absent in patients with single-vessel disease but became more common with increasing numbers of obstructed coronary vessels. We further examined the incidence of collaterals in 157 patients undergoing coronary artery bypass for chronic angina in the same nine-month period. More collaterals were again noted with increasing numbers of obstructed vessels (57 per cent with double-vessel disease, 75 per cent

TABLE 2 Morbidity in 41 cases of acute coronary insufficiency

Complication	No.
Atrial arrhythmia	6
Bleeding, reoperation	5
Ventricular arrhythmia	3
Congestive cardiac failure	2
Renal failure	2
Transient hemiplegia	1
Pulmonary infarction	1
Myocardial infarction	3

with triple-vessel disease) but in this group 39 per cent of patients with single-vessel disease had developed collaterals. These differences were also significant by a  $\chi^2$  test ( $P < 0.001$ ). Patients with multi-vessel disease, as might be expected (Table 1), showed proportionally more evidence of impaired ventricular wall motion and raised end diastolic pressures. Previous myocardial infarction was usually sited inferiorly; these patients developed coronary insufficiency when a critical stenosis appeared in one or more of the branches of the vessel supplying the collaterals, usually the left anterior descending and less commonly the circumflex or obtuse marginal artery. Revascularization then required multiple grafts. Diffuse disease was also common in the group with chronic angina, and they too almost invariably required multiple grafts.

Our findings suggest that patients with rapidly developing obstruction, especially in the proximal left anterior descending artery, may not have time to develop adequate collaterals and then present acutely with coronary insufficiency. These patients may be particularly at risk of myocardial infarction and sudden death.

The paucity of collaterals in single-vessel disease noted in this series has been confirmed by others. Scanlon *et al.* (1973), reporting on patients with coronary insufficiency, noted a significantly low (5.5 per cent) incidence of collaterals in patients with single-vessel disease rising to 80 per cent in those with more than three-vessel disease ( $P < 0.001$ ). These findings are of particular interest when related to recent studies on retrograde coronary flow. Parker *et al.* (1974), comparing patients with coronary insufficiency and chronic angina, the degree of obstruction being severe and approximately equal in both groups, noted much diminished flows in those with coronary insufficiency due to apparent lack of collaterals. In view of this pathophysiology it is not surprising that insufficiency progresses to myocardial infarction in from 20–40 per cent of patients (Wood, 1961; Gazes *et al.*, 1973; Krauss *et al.*, 1972; Vakil, 1964), commonly within three months of the onset of symptoms (Wood, 1961; Conti *et al.*, 1973; Fulton *et al.*, 1972). Even higher figures of 71–92 per cent have been noted (Goodin *et al.*, 1973; Conti *et al.*, 1973; Sustaita *et al.*, 1973). Furthermore 39–60 per cent of patients with myocardial infarctions give a previous history of coronary insufficiency (Wood, 1961; Vakil, 1964; Fulton *et al.*, 1972).

The chance of the myocardial infarction being fatal is fairly high in patients with coronary insufficiency (Goodin *et al.*, 1973). Goodin, in a review of seven medically managed series of patients with coronary insufficiency, noted a mortality of

between 15 per cent and 50 per cent at one year, whereas Wilson (1973), reviewing eight similar series (four series were partially common to both reviewers), estimated a 10–25 per cent mortality in the 20 months after the onset of symptoms of insufficiency. Fulton *et al.* (1972), in a carefully conducted prospective Scottish community study, recorded a low, 14 per cent, myocardial infarction rate and a two per cent mortality in the three-month period after the onset of symptoms of coronary insufficiency. They also noted a further group of 110 patients with myocardial infarctions, 60 per cent of whom had had preceding coronary insufficiency symptoms, but only 25 per cent of these had reported their symptoms to their doctors. Another 79 patients died suddenly in the same three-month period, the 'majority' having no known preceding chest pain. They concluded that sudden death is a relatively infrequent sequel of coronary insufficiency and is seldom preceded by ischaemic symptoms which are reported to a physician. However, if 75 per cent of a group of patients (50 patients) fail to report symptoms of coronary insufficiency and then go on to sustain a myocardial infarction, probably a considerable number of the 79 sudden deaths may have been sequelae of undeclared coronary insufficiency. Some of these deaths may be related to misplaced national stoicism.

After the demonstration of a similar distribution and severity of coronary artery lesions in patients with coronary insufficiency, chronic angina, and angina with myocardial infarction (Proudfit, Shirey, and Sones, 1967) and recognition of the symptomatic success of coronary bypass for refractory chronic angina, it seemed logical to extend the operation to patients with coronary insufficiency. Having in the past lost patients with coronary insufficiency while awaiting operation (Anderson *et al.*, 1972), and knowing that emergency coronary arteriography does not carry an increased risk in our hospital, there seemed no reason to delay angiography and subsequent surgery. If the surgery could then be performed with an acceptably low incidence of death and perioperative myocardial infarction the two immediate hazards of non-operative management would have been overcome.

Many patients have now been operated on in various clinics. Overall operative mortality rates of 8.3 per cent (Goodin *et al.*, 1973) (266 patients) or 4.3 per cent (Thomas *et al.*, 1973) (420 patients) have been reported. At least two other series of over 40 patients undergoing surgery for coronary insufficiency without operative mortality have been reported (Auer *et al.*, 1971; Bolooki *et al.*, 1974). Only two patients in this series had stenosis of the left main coronary artery and in one of these the

right coronary artery was also occluded. This patient arrested after coronary angiography but thereafter successfully underwent triple vein grafting. The dangers of coronary angiography in the presence of this lesion have been documented (Cohen *et al.*, 1971). The importance of priming the extracorporeal pump before the induction of anaesthesia and the need to get the patient quickly on to full bypass have also been emphasized (Zeft *et al.*, 1974). Though our patient undoubtedly sustained considerable cardiac damage after arrest, the absence of any evidence of transmural infarction at any time in the postoperative period suggests that external and internal massage are still of value even in the presence of severe coronary artery disease. It was also of interest that this patient remained in refractory ventricular fibrillation (the heart being vented) until after revascularization of the left anterior descending artery, the first vessel to be grafted.

Atrial arrhythmias and postoperative bleeding have been our major causes of morbidity. None of the arrhythmias was haemodynamically significant and all responded to increased digitalis therapy. The high incidence of postoperative bleeding was largely due to a group of patients who were inadequately warmed on coming off bypass, cooled further thereafter, became vasoconstricted and hypertensive, and then bled excessively. Attention to thorough rewarming and the judicious use of vasodilators have subsequently greatly reduced this problem. Renal function in both patients with renal failure returned to normal without dialysis before discharge.

Follow-up of our patients (mean 9.7 months) showed a gratifying absence of symptomatic or documented late myocardial infarction, a single late death (grafts patent at necropsy), and abolition of angina in 80 per cent of survivors. Bolooki *et al.* (1974) noted similar findings at six months to four and a half years after operation, whereas Bonchek *et al.* (1974) reported a late mortality of two per cent, a late myocardial infarction rate of six per cent, and abolition of symptoms in 45 per cent of cases at mean follow-up of two years. Follow-up studies at four months (Selden *et al.*, 1974) and seven months (Conti *et al.*, 1975) in two randomized trials of surgical versus medical therapy for acute coronary insufficiency have shown more angina in medically treated patients, significantly so in the larger series (Conti *et al.*, 1975). Selden *et al.* (1974) further showed significantly higher exercise and heart-rate thresholds for angina and significantly greater myocardial lactate extraction during tachycardia in the surgically treated patients.

Analysis of employment status at follow-up

showed that, excluding nine patients who were retired before surgery (seven were over 60 years of age), only three patients failed to return to full-time work. A high rate of return to work is to be expected in a group of community-hospital treated patients with short histories of preoperative unemployment and excellent relief of symptoms after surgery (Anderson, 1973). In view of the potentially large number of patients who may undergo this treatment and the costs involved it is encouraging to note that 85 per cent of patients in this series were restored to full-time gainful occupation, often within two or three months of operation.

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